

In the Specification

Please replace paragraphs [0001] through [0004] with the following:

Related Application

This is a §371 of International Application No. PCT/FR02/01832, with an international filing date of May 31, 2002 (WO 02/097407, published December 5, 2002), which is based on French Patent Application No. 01/07216, filed June 1, 2001.

Field of the Invention

~~The present~~ This invention pertains to a method and a device for the detection of chemical species present in condensed medium. More particularly, the invention pertains to

~~——The envisaged fields of application are notably those of monitoring the composition of the aqueous effluents discharged by a water purification station or any other industrial operation discharging effluents and—~~

~~——Another envisaged field of application is that of monitoring the formation of a chemical compound in an industrial production process.~~

Background

The monitoring of industrial discharges in nature in liquid form is generally performed visually and by analysis of discharged liquid samples according to a specific method for each chemical species being investigated. Furthermore, when monitoring a large expanse of aqueous effluent that might comprise chemical species not uniformly distributed on said expanse, it is necessary to collect multiple samples at different sites in order to localize the origin of the production of said species. The time required for the analysis of the sample and the replacement rate of said effluent affect the diagnosis with regard to this localization.

Please replace paragraphs [0008] through [0010] with the following:

~~A problem which exists and which the present invention intends to resolve is that of providing~~ It would therefore be advantageous to provide a method for the detection of chemical species present in a condensed medium which not only makes it possible to precisely detect the nature of the chemical species present in said condensed medium with less costly detection means, but also which enables excitation of the surface of said condensed medium with means of reduced power and thus equally less costly.

Summary of the Invention

This invention relates to a method for detecting chemical species present in a condensed medium including determining characteristic wavelengths and intensity values of back-scattered electromagnetic emission signals due to fluorescence of chemical species excited in response to a multiplicity of electromagnetic excitations of distinct wavelengths of at least one chemical species that could be contained in the condensed medium; successively exciting a multiplicity of surface elements of a surface portion of the condensed medium with a laser beam having tunable wavelength capable of taking on at least one of the distinct wavelengths of the multiplicity of electromagnetic excitations; successively recording wavelengths and intensity values of the electromagnetic emission signals back-scattered by each of the surface elements in response to the electromagnetic excitations produced by the beam; comparing at least one excitation wavelength and at least one corresponding emission wavelength of the recorded intensity value of the electromagnetic signal back-scattered by each of the surface elements with the determined characteristic intensity value of the back-scattered electromagnetic signal of the chemical species that could be contained in the surface portion; and determining the presence of the chemical species in each of the surface elements when the recorded

intensity value of the electromagnetic signal back-scattered by the surface element is greater than a threshold defined at least by the determined characteristic intensity value of the back-scattered electromagnetic signal of the chemical species.

This invention also relates to an apparatus for detecting chemical species present in a condensed medium including means for determining characteristics wavelengths and intensity values of back-scattered electromagnetic emission signals in response to a multiplicity of electromagnetic excitations of distinct wavelengths of at least one chemical species that could be contained in the condensed medium; a laser generator producing a laser beam to successively excite a multiplicity of surface elements of a surface portion of the condensed medium according to wavelengths capable of taking on at least the values of the distinct wavelengths of the multiplicity of electromagnetic excitations; means for successively recording the wavelengths and intensity values of electromagnetic emission signals back-scattered by each of the surface elements in response to the electromagnetic excitations produced by the beam; comparison and determination means for comparing at least one excitation wavelength and at least one corresponding emission wavelength the recorded intensity value of the electromagnetic signal back-scattered by each of the surface elements to the determined characteristic intensity value of the back-scattered electromagnetic signal of the chemical species that could be contained in the condensed medium and for determining the presence of the chemical species in each of the surface elements when the recorded intensity value of the electromagnetic signal back-scattered by the surface elements is greater than a threshold defined at least by the determined characteristic intensity value of the back-scattered electromagnetic signal of the chemical species; and a computer connected to the recording means which has a memory capable of storing simultaneously the wavelength of the back-scattered signals and its

intensity for sequential archiving, surface element by surface element, indexed by the displacement means and stored in the memory of the computer the measurements of intensity and wavelengths of the back-scattered signals.

Brief Description of the Drawings

Other specific characteristics and advantages will become apparent from the description below of specific modes of implementation of the invention presented in a nonlimitative indicative manner with reference to the attached drawings in which:

Fig. 1 is a schematic view showing the detection device according to the invention; and

Fig. 2 is a representation of a spectrum which could be obtained by means of the device according to the invention.

Detailed Description

~~For this purpose, the present~~ The invention proposes provides a method for the detection of chemical species comprising the following steps: ~~one determines~~ determining the characteristic wavelengths and intensity values of back-scattered electromagnetic signals in response to a multiplicity of electromagnetic excitations of distinct wavelengths, of at least one chemical species which can be contained in said condensed medium; ~~one excites successively~~ exciting a multiplicity of surface elements of a portion of the surface of said condensed medium with a laser beams, the tunable wavelength of which can take on at least the values of said distinct wavelengths of said multiplicity of electromagnetic excitation; ~~one records successively~~ recording the wavelengths and ~~the~~ intensity values of the electromagnetic emission signals back-scattered by each of said surface elements in response to the electromagnetic excitations produced by said beam; ~~one compares at~~ comparing at least one excitation wavelength and at at least one corresponding emission wavelength

the recorded intensity value of said back-scattered electromagnetic signal of each of said surface elements at said characteristic intensity value determined from said back-scattered electromagnetic signal of said chemical species which could be contained in said surface portion; and ~~one determines~~ determining the presence of said chemical species in each of said surface elements when said recorded intensity value of said electromagnetic signal back-scattered by said surface element is greater than a threshold defined at least by said given characteristic intensity value of said back-scattered electromagnetic signal of said chemical species.

Thus, the method is based on the analysis of back-scattered electromagnetic signals stemming from the fluorescence of chemical species excited by a beam from laser means, said signals being characteristic of said chemical species. At given excitation wavelengths of the laser beam, the targeted chemical species diffuse the electromagnetic signals, the intensities and wavelengths of which are characteristic of said species. In this manner, by exciting a given chemical species with laser means and by varying the excitation frequency one obtains in response back-scattered signals the wavelengths and intensities of which are characteristic.

Please replace paragraph [0013] with the following:

However, as will be explained in greater detail below in the continuation of the description, a chemical species can ~~present~~ have multiple characteristic emission signals at different wavelengths in response to a single excitation wavelength. In this case, the incident radiation ~~would~~ can be tuned solely on this excitation wavelength if only this chemical species is being investigated.

Please replace paragraph [0016] with the following:

According to a preferred mode of implementation of the invention, one records in parallel the intensity values of said back-scattered electromagnetic emission signals and their corresponding

wavelength is recorded as well. In this manner, it is possible to very rapidly record the spectra of the chemical species present in the surface portion.

Please replace paragraph [0018] with the following:

~~A second object of the present~~ The invention is to ~~propose~~ provide a device for the detection of chemical species present in a condensed medium, ~~which.~~ The device comprises: means for determining the characteristic wavelengths and intensity values of back-scattered electromagnetic emission signals in response to a multiplicity of electromagnetic excitations of distinct wavelengths of at least one chemical species that could be contained in said condensed medium; laser means producing a beam for successively exciting a multiplicity of surface elements of a surface portion of said condensed medium according to wavelengths capable of taking at least the values of said distinct wavelengths of said multiplicity of electromagnetic excitations; means for successively recording the wavelengths and the intensity values of electromagnetic emission signals back-scattered by each of said surface elements in response to the electromagnetic excitations produced by said beam; and comparison and determination means for comparing at ~~at~~ least one excitation wavelength and at least one corresponding emission wavelength the recorded intensity value of said electromagnetic signal back-scattered by each of said surface elements at said given characteristic intensity value of said back-scattered electromagnetic signal of said chemical species that could be contained in said condensed medium and for determining the presence of said chemical species in each of said surface elements when said recorded intensity value of said electromagnetic signal back-scattered by said surface elements is greater than a threshold defined at least by said given characteristic intensity value of said back-scattered electromagnetic signal of said chemical species.

Please replace paragraphs [0020] through [0022] with the following:

According to a particular mode of implementation of the invention, said laser means comprises: a pump laser associated with a frequency doubler; and a parametric oscillator to which said pump laser is coupled in a manner such as to emit radiation the tunable wavelength of which is in the range between 200 and 800 nm. In this manner, a large number of chemical species can be identified and distinguished from each other.

According to a particular advantageous characteristic, said laser means producing a beam comprises orientation means of said beam for exciting said multiplicity of surface elements of said surface portion of said condensed medium in a manner to analyze the back-scattered electromagnetic emission signals stemming from each of said surface elements and of determining the presence of at least one of said chemical species in each of said surface elements of said surface portion.

As will be explained in greater detail in the continuation of the description, the displacement means comprises mobile mirrors for orienting the beam of each of the surface elements, with these displacement means being controlled by control means.

Please replace paragraphs [0025] through [0030] with the following:

~~Figure~~ Turning now to the drawings, Fig. 1 illustrates the detection device according to the invention which ~~presents~~ has laser means 10 forming an excitation beam 12, means 14 for recording a back-scattered signal 16 and comparison and determination means 18 contained in the central unit of a computer 20. Moreover, the central unit comprises programs for controlling the entirety of the device according to the invention.

The laser means 10 comprises a pulsed laser 22 of the NdYAG type coupled to a frequency converter unit 24, for example, a frequency doubler or tripler[[,]] such that the first beam 26

stemming from it is ~~oriented~~ directed to an optical parametric oscillator 28 providing at least one second beam 30 which is directed to a second frequency doubler 32. The parametric oscillator 28 makes it possible to vary in a continuous manner the wavelength of the second beam 30.

In a particularly advantageous manner, said laser means comprises a pumping source operating in femtosecond mode and forming a compact system. These laser means have the advantage of being available at low cost.

The tunable laser means 10 enables provision of an excitation beam 12 with a section of several cm^2 at a distance of 100 m and the wavelength of which can vary at least between 220 and 750 nm, wavelength interval within which the chemical species that could be excited ~~present~~ have characteristic spectra.

The pump laser 22 can be advantageously replaced by a diode system that ~~presents~~ has the same advantages.

Please replace paragraphs [0032] and [0033] with the following:

Said Such chemical compounds can emit a back-scattered electromagnetic signal 16 in response to the excitation induced by the excitation beam 21, said back-scattered electromagnetic signal 16 prints the same optical path as the excitation beam 12 up to the transparent means 34 that orient the back-scattered signal 16 to the recording means 14.

These recording means 14 comprises a spectrometer 40 capable of determining the wavelengths of the back-scattered electromagnetic signals 16 and coupled to detector means 42 constituted by a matrix of photoelectric sensors, for example, CCD, capable of determining the intensities at a position of the back-scattered signals 16. Moreover, the recording means 14 are

linked to the center unit of the computer 20 which has a memory that can store simultaneously, notably, the wavelength of the back-scattered signal 16 and its intensity.

Please replace paragraph [0037] with the following:

The characterization of the chemical species will be described with reference to the means of ~~figure~~ Fig. 2 illustrating the spectra of a mixture containing at least two aromatic hydrocarbons: anthracene and a benzopyrene.